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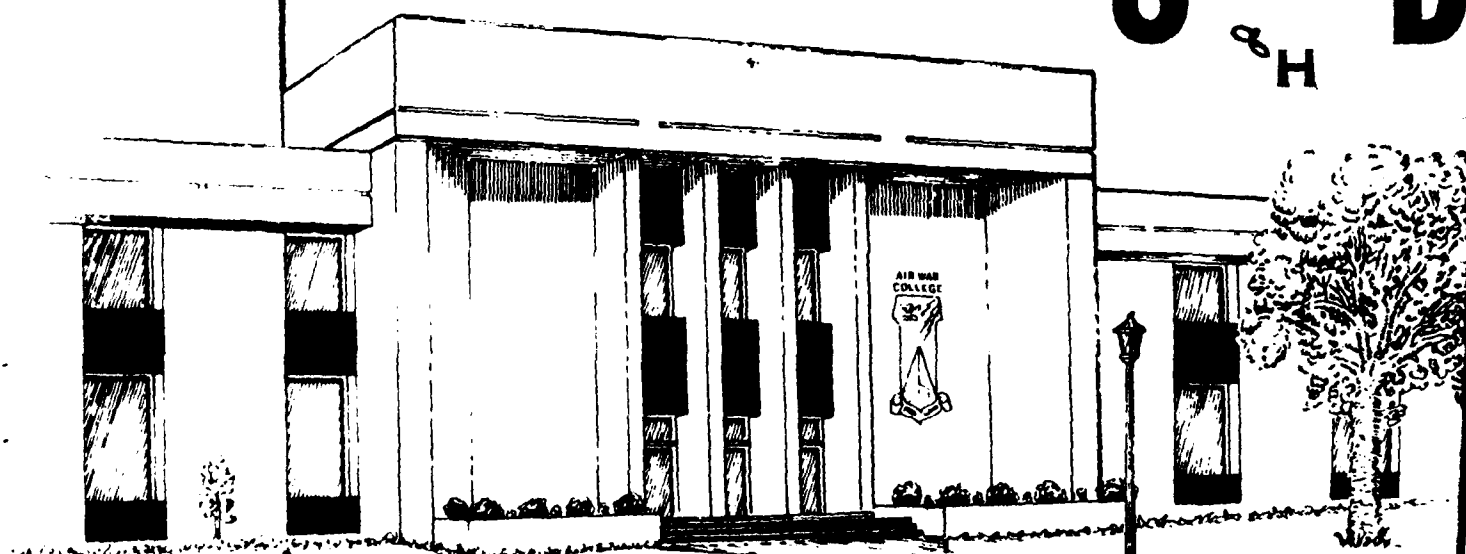
## RESEARCH REPORT

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LOGISTIC SUPPORT PLANNING FOR  
NEW AIRCRAFT WEAPON SYSTEMS

By COLONEL MOHAMMAD J. MARASHDEH, RJAF

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LOGISTIC SUPPORT PLANNING FOR  
NEW AIRCRAFT WEAPON SYSTEMS

by

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Colonel, RJAF

A RESEARCH REPORT SUBMITTED TO THE FACULTY  
IN  
FULFILLMENT OF THE RESEARCH  
REQUIREMENT

Research Advisor: Colonel John A. Brantner

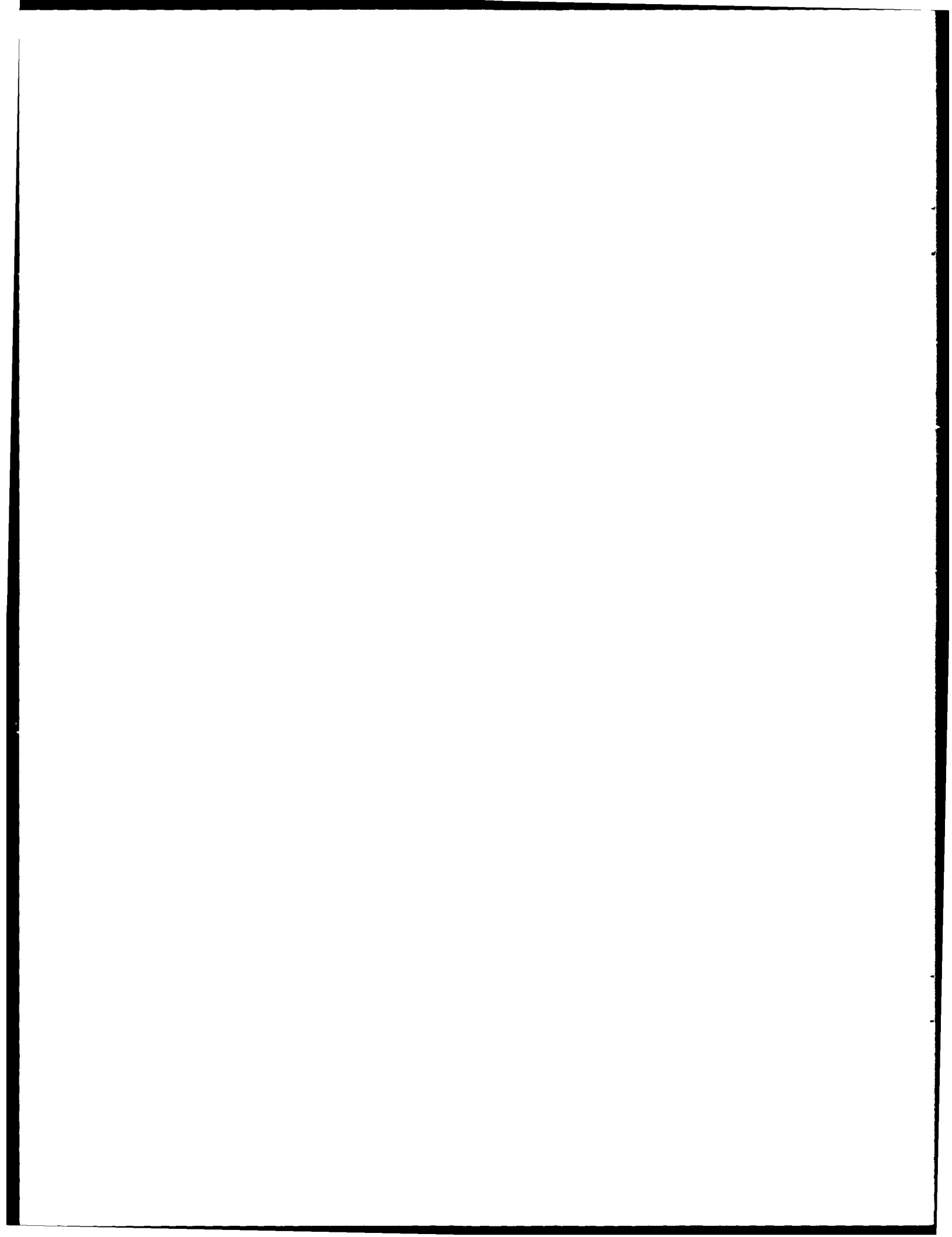
MAXWELL AIR FORCE BASE, ALABAMA

May 1988

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: Logistic Support Planning For New Aircraft  
Weapon Systems

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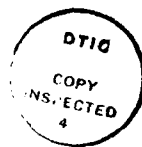
Identifies logistic support problems that need to be considered when acquiring new aircraft weapon systems.

Discusses logistic support elements and planning decisions that are made in the early stages of procurement to ensure the availability of the aircraft for the required mission. Failure to evaluate the aircraft logistically and to accomplish proper logistic support planning are seen as the main factors that influence system effectiveness, operational readiness and life cycle cost.

# BIOGRAPHICAL SKETCH

Colonel Mohammad J. Marashdeh of the Royal Jordanian Air Force was born in Irbid, Jordan in 1946. He joined the Air Force in 1964 when he entered the Hellenic Air Academy and graduated in 1969 with a BS in Aeronautical Engineering. Since then he worked in the field of aircraft and munitions maintenance. In 1977, he was assigned as Chief of Maintenance at Prince Hassan Air Base. He attended the Air Command and Staff College Class of 1979 at Maxwell AFB. In 1979 he was assigned as Chief of Maintenance at King Hussein Air Base. In 1984, he completed his MS studies in the field of Aeronautics at Carnfield Institute of Technology, England. His assignment prior to Air War College was Chief of Munitions and Armament branch at RJAF HQ in Amman. Colonel Marashdeh is a graduate of the Air War College, Class of 1988.

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## CHAPTER I

### INTRODUCTION

The purpose of this paper is to describe a logistic support planning procedure that can be applied when acquiring and introducing a new aircraft. New aircraft weapon systems are generally highly complex and very expensive. This increasing complexity has an impact on the ability to support and maintain these weapon systems. When procuring new aircraft, the evaluation should not cover only performance and operational requirements but also logistic supportability and maintainability. Effectiveness in maintaining operational readiness of aircraft is of paramount importance. Sufficient logistic resources must be provided from the time the system is introduced to assure continuing serviceability of units required to meet planned objectives. *Major life cycle costs*

To achieve this the following steps should be followed. First, problems in current aircraft logistic systems should be identified so as to reduce these logistic problems when acquiring new aircraft. Second, aircraft should be evaluated logistically to achieve the operational requirements. *Supportability* Third, when acquiring new aircraft which *Cost* meet performance and operational requirements, logistic planning should be accomplished to ensure the availability of the aircraft for the required mission. *Life cycle*

This study consists of six chapters in the following areas:

Logistic Problems. Chapter 2 discusses logistic problems in current aircraft. These problems are in the areas of aircraft subsystems, support equipment, maintenance, spares estimation and high life cycle costs. These problems should be considered when evaluating new aircraft.

Logistic Support Elements. Chapter 3 contains the areas where major support planning decisions are made. These decisions fall into the task of determining the quantity and distribution of initial spares, the amount of AGE and new facilities, maintenance support requirement, personnel and their associated training, the level of repair, technical data, and supply support.

Spares Estimation. Chapter 4 discusses spares estimation and factors that affect the accuracy of this process.

Operating and Support Costs. New aircraft weapon systems are very expensive. This is due to life 2 cycle cost which includes operating and support cost. Chapter 5 discusses the way in which operating and support cost can be estimated.

## CHAPTER II

### LOGISTIC SUPPORT PROBLEMS IN CURRENT AIRCRAFT

The need for new weapon systems emerges from a variety of sources; e.g., operational experience, threat assessment, analysis of current weapon system capabilities, technological advances, and opportunities to reduce operating and support obstacles and costs. In the drive to procure this new weapon system, performance requirements usually override logistical requirements. After all, if the weapon system does not perform as required against the threat, there is not much point in acquiring that weapon system. However, if due to a logistic problem, that weapon system is not available for its mission; it is just as useless as if it did not meet its performance requirements. System readiness and sustainability are as important as system performance.(1:24)

All aircraft developed for the military have had some type of logistic problems. It is necessary to identify these potential problems so as to eliminate or greatly reduce these logistic support problems in new aircraft. The problem areas are in aircraft subsystems, ground support equipment, maintainability, reliability, spares and life cycle costs.

#### Aircraft Subsystems

Aircraft avionics are major problem areas in current

aircraft. Avionics are affected by their sensitivity to adverse conditions. The number of parts in the subassemblies are increasing with sophistication. The high number of components makes avionics problems difficult to troubleshoot. Avionics subsystems problems are difficult to diagnose and it is time-consuming to isolate faults. A part of this problem is due to inadequate test equipment. These problems combine to increase the maintenance repair time required by this subsystem.

Another aircraft subsystem that characteristically causes logistical problems is aircraft engines. Increasing performance and mission requirements have increased the complexity of aircraft engines. They must perform under a variety of adverse conditions. Many of the components are subjected to extremely high temperatures. As a result, engine components are subject to high failure rates. Once a failure occurs, the engine experiences a long maintenance down time to repair. The aircraft's design should be modular. If the engine could be broken into modules, repair time would be reduced and the maintenance load eased.

All aircraft subsystems, when they fail, must be accessible for repair. They should be built in the form of Line Replaceable Units (LRU). LRU's must be accessible from the ground or cockpit without having to remove equipment out of the way. Fuel cell leaks also have been a time-consuming

item to repair which involves draining the tanks, resealing, allowing the seal to cure and testing. Self-sealing fuel cells should be incorporated. Resealable cells would reduce much of the maintenance load.

#### Ground Support Equipment

Ground support equipment can also cause a multitude of logistical problems. Some of the major problems with ground support equipment stems from the acquisition process. Standardization is one of the main problems. Often there are different types of equipment designed to do similar things. Much of this problem comes from support equipment requirements not being properly screened to determine if there is usable common support equipment already in the inventory. Another problem arises because often no training is provided by the manufacturer prior to receipt of new support equipment into the inventory. These problems result in support equipment not having high reliability and often leads to rapidly rising cost during the life cycle.

The ground support equipment should be kept to a minimum. The aircraft should have a self starting capability. Deployments and dispersals would be easier with this capability in that it would reduce the amount of maintenance, material, and personnel that would have to accompany aircraft when they are dispersed.

### Maintainability and Reliability

Reliability and ease of maintenance must be in the design of the aircraft. Factors which determine maximum system use are: time needed for corrective or unscheduled maintenance; time for preventive or scheduled maintenance and the sum of them, which gives the total maintenance time. The time for maintenance will depend on time for fault location and access to the failed components. The frequency of corrective or unscheduled maintenance is largely a function of the component failure rate. Failure rate is the frequency at which a failure occurs and is usually measured in number of failures per hour. The reciprocal value of this failure rate is the mean time between failures (MTBF). (2:12)

An important factor for determining material requirements is the mean time between failure rates estimated for recoverable items. It is difficult to estimate accurately the MTBF for a new item. Considering the importance of MTBF to maintenance planning and provisioning, a higher degree of accuracy is needed. Initial estimates of MTBF which are too high will result in inadequate resources. Conversely, estimates which are too low will result in planning an excess of resources. Estimated failure rates provided by manufacturers are not reliable and vary considerably from later actual data. (3:3-4) The aircraft to be procured must have a high system MTBF. High reliability

of individual components does not guarantee this because of the large number of components in many subsystems. If common functions of different subsystems were integrated, the number of specialized components could be reduced and redundancy incorporated. This redundancy would increase overall system reliability. Survivability would also be enhanced by selected system redundancy especially if the redundant systems were located on opposite sides of the aircraft. Then combat damage would be less likely to destroy the aircraft subsystems and render further flight impossible. Reliability and maintainability are key factors that influence system effectiveness, logistic support requirement, and life cycle cost. Reliability and maintainability data are used to develop the baseline for analyzing a weapon system's peacetime readiness and wartime deployment, and the associated support costs.(2:12)

### Spares

In order to attain high levels of operational readiness during the initial support period of an aircraft, it is necessary to predict potential logistic support problems. The logistic assets supporting new weapon systems; i.e., spare parts, test equipment, etc., are requiring longer procurement lead times. This is due to the increased sophistication of multifunction weapon system components.

Because of increased procurement lead times, a shortage in logistic assets can jeopardize operational readiness goals. In the provisioning of spare parts, the question always arises. How many spare parts are necessary to maintain an equipment for a given period of time? Acquiring too many spares causes excesses and higher inventory costs, as well as opportunity losses. Conversely if not enough spare parts are procured because of faulty factoring and inaccurate MTBF, increased costs are incurred. Expedited deliveries and untimely acquisition would be required to get the items to their needed locations to made up for initial shortages. These shortages of spares affect both readiness and sustainability and cost.(4:1-3)

#### Life Cycle Cost

Life cycle cost is an effective way of quantifying logistics supportability. Increasing life cycle cost indicates decreasing supportability. Generally, attention is focused on the cost of buying a new system, while life cycle cost, or the cost of buying and maintaining a weapon system over its expected life, is given less attention. "The need to address total system cost (in lieu of acquisition cost only) is evident, and experience has indicated that logistics support constitutes a major contribution to life cycle cost."(5:51) Recently operating and support costs have grown



so rapidly they now dominate as the major element in a system total life cycle cost. "Operating and support costs are the costs of operation, maintenance, and follow on logistics support of the end item and its associated support systems."(6:107)

## CHAPTER III

### LOGISTIC SUPPORT PLANNING ELEMENTS

The 1966 Dictionary of United States Military Terms for Joint Usage defines logistics as:

. . . the science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense those aspects of military operations which deal with: (1) design and development, acquisition, storage, movement, distribution, maintenance, evaluation and disposition of material; (2) movement, evacuation and hospitalization of personnel; (3) acquisition or construction, maintenance, operation and disposition of facilities; and (4) acquisition or furnishing of services.

The 1968 joint commanders' report (Basic Principles of Logistic Panel, Final Report) defines logistics as:

. . . the art and science of creating and maintaining a military capability. It consists of the process of determining requirements, acquisition, distribution and maintenance of material.(6:17)

When acquiring new weapon system which meets the performance requirements, logistics planning should be accomplished to ensure the availability of the aircraft for the required mission. Because current aircraft rely heavily on logistics support to perform their mission, logistics support planning should be considered in the early stages of procurement. The effectiveness of the unit is not just a function of the performance capability of the aircraft but is also a function of the amount of support available. An aircraft is useless when it sits on the ground being

serviced. An aircraft may as well not be at the battle front if it is grounded waiting for a replacement part to be shipped from the manufacturer. Reliance such as this tends to diminish the effectiveness of that aircraft. "Ultimately, the limiting factor on what any military force can do depends on its logistics support." (7:2)

The primary question involving the logistic system concerns readiness. Is the logistic system capable of supporting sustained combat operations? Readiness determinations are focused on the combat unit level. They are geared to answer the following questions.

"Is the unit equipped, manned, and trained to meet its wartime tasks and assignments? Does it have on hand those supplies, munitions, and specialized items to meet its combat commitments? Underlying this assessment is the assumption that logistics system can sustain operations. This brings up the following questions. What is the stock availability? What is the availability of bits and pieces to support maintenance lines? What is our depot maintenance capability? What is our transportation and associated capability to prepare and move material through the system? Today we have individual performance indicators such as not mission capable supply (NMCS) and backorder rates, and pipeline times, to assist us in making these assessments." (8:30)

Another area of great interest is maintenance. It accounts for very large costs. Most of the people in logistics are involved in maintenance. The questions to be asked are the following. What are the levels of required maintenance support? What major elements of logistics support are required at each level (e.g., support equipment,

spares, personnel)? Where is the maintenance to be accomplished? What maintenance facilities are required and where are they to be geographically located? What are the required support effectiveness characteristics (e.g., availability and reliability of support material, probability of spare parts availability at a given level of maintenance, turn around times, pipeline times, maintenance down time, repair times)? What is the environmental profile in which maintenance is to be accomplished?(8:32)

Using mission reliability factors (successful sorties and sorties attempted), logistic reliability factors (e.g., mean time and mean sortic between maintenance), and maintainability factors (e.g., maintenance man-hours per/flying hour, and mean time to repair), organizations can:

1. Determine manufacturer performance relating to established reliability and maintainability goals.
2. Estimate manpower requirements for base and depot repair.
3. Estimate spares requirement for logistic support.
4. Establish life cycle, target, and measured logistic support costs.
5. Identify variance in estimated and actual performance levels.
6. Determine the impact these variances have on reliability, maintainability, and other logistic support elements.

The major support planning decisions made during weapon system acquisition fall into the tasks of determining the quantity and distribution of the following:

1. Maintenance Planning - concepts and requirements for each level of projected maintenance during the life of a system or equipment.
2. Support and test equipment - all tools, monitoring and checkout equipment, calibration equipment, handling equipment, fixtures, etc., necessary to support scheduled and unscheduled maintenance actions.
3. Supply support - all spares, repair parts, consumables, special supplies and related inventories needed to support scheduled and unscheduled maintenance actions associated with the prime mission equipment, test and support equipment, facilities and training equipment.
4. Personnel and training - all personnel, training, and training equipment necessary for the accomplishment of system maintenance functions.
5. Facilities - physical plant, real estate, intermediate shops, overhaul and repair depots, etc., required to support maintenance at all levels.
6. Technical data - drawings, operating and maintenance instructions, modification instructions, inspections and calibration procedures, etc., required to support system/product installation, checkout, operation, and maintenance.
7. Transportation and handling - special provisions, containers, equipment, and supplies necessary to support packaging, preservation, storage, handling and/or transportation of prime equipment, test and support equipment, spare/repair parts, personnel, technical data and facilities.(5:56)

#### Maintenance Planning

Maintenance planning establishes requirements for

each level of equipment maintenance to be performed during its useful life. As such, maintenance planning defines the actions and supporting requirements necessary to maintain the weapon system and equipment in its prescribed state of operation.(10:210) Maintenance functions include checkout, servicing, inspection, fault isolation, replacement, modification and overhaul. The degree to which these various functions to be performed by organizational, intermediate, or depot level must be defined. The maintenance plan should respond first to readiness requirements and next to economies in the commitment of supporting resources. Maintenance planning evaluates current and projected maintenance capabilities. Specific maintenance actions to be performed at various levels of maintenance and the resource requirements needed to support these actions should be identified.(6:47)

Aircraft maintenance is accomplished at one of three levels. They are Organizational, Intermediate (Field), and Depot. Normally maintenance at the lowest level is limited to routine servicing, inspections and replacement of defective or unserviceable parts and minor subassemblies. The intermediate and depot level activities generally have more equipment, facilities and better qualified technicians than are available at the organizational level. Depot maintenance is the highest level and that activity will

possess the most sophisticated equipment and the greatest maintenance capability. Intermediate level maintenance is usually performed in fixed shops with one facility providing support to one or more organizations. Depot level maintenance is usually accomplished at fixed locations or by on-site teams. Each level of maintenance has inherent costs and economies that must be considered in determining the appropriate level of repair for an item. For example, tooling costs for depot repair of an item are usually less than they would be for intermediate level repair. This is due to economy of scale. Tools at the depot level can be operated at or near capacity while at the intermediate level they might be idle much of the time because of the low volume of reparable generated at a given location. Furthermore, more than one set of tooling would be required to support a number of different intermediate level repair locations.(10:67)

#### In-Country Maintenance

The need to be able to operate and maintain all owned weapon systems without outside assistance is present in the strategic thinking of all nations. The desire for independence and self-reliance in the operation and maintenance of a nation's defense force is driven by the fear that foreign sources might be closed off when most needed.

Any new weapon system added to the inventory will require maintenance procedures which are similar to others already carried out for existing equipment. It will most likely also require new procedures, using technologies that are new. It is important to identify these new procedures and evaluate whether they can be carried out successfully by using the nation's current industrial base. Where new industry base requirements are identified, the next stage is to look at the most cost effective way of satisfying them, bearing in mind national, economic and defense philosophies.

It may be possible at the time of purchasing the weapon system, to arrange for the transfer of any desired technologies. Such transfers may be arranged with few restrictions on their use or they may be made under strict license conditions which preclude their use in other applications. Any technology transfer arrangements are probably best negotiated concurrently with the contract for the weapon system, as this is the time when the supplier is most likely to be amenable to entering into such agreements, due to his desire to sell the equipment.

#### Support and Test Equipment

The ability of an activity to perform required maintenance depends on the adequacy and availability of the support and test equipment. The purpose of the support and



test equipment planning is to assure that the required support and test equipment is available to the operating forces and supporting maintenance activities in a timely manner.(10:14) Their availability is the result of careful planning and scheduling to make sure that the equipment needed to support the system is delivered with the system. Support and test equipment consists of tools, metrology and calibration equipment, performance monitoring and fault isolation equipment, and handling devices that are peculiar to the system or that are commercially available or currently in the inventory.(11:63)

Quantifying equipment requirements is a difficult task. For example, when determining how many ground starting units are needed to support a squadron of 24 aircraft, one needs to know the deployment conditions. If the aircraft are to be dispersed in bunkers around the perimeter of a runway, more starting units will be needed than if the aircraft will be lined up near the maintenance hangar. Failure to plan for the first case will result in extra maintenance manhours expended for towing the air starting units around the airfield. So the effectiveness of the maintenance activity is affected by the availability of that ground equipment when it is needed. The resultant estimates should define both existing support equipment that may be utilized and those requirements needing procurement.

## Supply Support

Maintaining operational readiness under diverse conditions of military use depends directly on the availability of the right supplies at the time and place they are needed. Supply support is an essential element of logistics and is responsible for timely provisioning, distribution and inventory replenishment of spares, repair parts and special supplies.(10:12)

Supply planning for spares and repair parts must be based upon technical inputs from the maintenance planner (e.g., system/equipment utilization rate, operating hours, failure rates, required field repair rates, locations, and selected maintenance items critical to safety and mission accomplishment). Supply planning for the availability of spare and repair parts depends upon the design characteristic of the system, its subsystems, components and supporting hardware. One design characteristic that impacts on spares requirement is the repair level. If the item is designed as a base level reparable item, the number of repair parts must be sufficient to fill supply needs at the bases that use the item. Item reliability, as expressed in failure rates, is another design characteristic that affects supply requirements. In general the higher the reliability of an item, the fewer number of spares or repair parts needed to support it.

Initial provisioning is the systematic determination of the number and types of spares and repair parts needed to support system operation for a fixed time period, usually one year. Usually the initial provisioning is accomplished based on repair level and parts reliability and the operational decisions such as number of bases where the system will be operated and forecasted hours of operation. Other specific supply requirements such as spares and repair parts for aircraft support equipment must also be established and provisioned. After the initial provisioning of spares and repair parts, the pipeline should be kept filled through inventory replenishment.

#### Technical Data

Technical data is necessary to develop, produce, deliver, operate and maintain operationally ready hardware. Technical data is necessary to conduct operations, training maintenance, supply, modification, repair and overhaul of the systems and equipment. Technical data includes maintenance and modification manuals, specifications, inspections test and calibration procedures and computer programs required to guide people performing operations and support tasks.(11:63)

Delivery of technical data at the same time its corresponding hardware is delivered is an important objective of logistic management. It is difficult and impractical to

maintain or operate much of the complex equipment now being produced without written guidance.

### Facilities

The purpose of the facilities program is to assure that all required facilities are available to the supporting activities in a timely manner concurrently with its prime systems and equipment. The ability to perform the mission could depend on the adequacy of facilities. Facilities planning is based on operations and maintenance analyses, equipment design drawing, specification and other documentation necessary for defining types of facilities required. An analysis is made to determine what facility capabilities are needed.(11:86)

Facilities plan requirements are prepared for inclusion in the logistic support plan requirements. They include criteria for development of:

1. Real estate and construction specification.
2. Primary facilities such as materials, power and communications, water, access roads and critical real property.
3. Support facilities for personnel, training, storage, transportation, and administration use.

There are many facility problems that create logistical problems. These include the lack of hangar space,

inadequate warehousing and shelters and washing facilities for aircraft. When procuring new weapon system an inventory of all sorts of facilities required should be prepared and then compared against what is available and what is planned to be added or deleted in the future.

#### Personnel and Training

The personnel and training program defines qualitative and quantitative requirements for trained personnel and training equipment to support a system through all life cycle phases. These requirements are translated into specific manning plans in terms of numbers and military skill classification. (9:93) The concept of operations, maintenance concepts, and complexity and sophistication of the system are important factors in determining the number and the skill of personnel required. Personnel requirements must be balanced against manpower availability. All deficits must be covered by firm training action and timely manpower commitment. Projection for training requirements must reflect attrition experience. Special requirements for training and training aids must also be established.

#### Transportation and Handling

This element includes the characteristics, actions and requirements necessary to insure the capability to

transport, preserve, package, and handle all equipment and support items. Attention to planning the transportation and handling aspects of equipment and spares can conserve funds. One solution to a transportation and handling problem is the adoption of the reusable "suitcase" type packages for high value, high density, reparable electronic equipment. Foam padded, prefitted, lightweight fiberglass suitcases are designed for quick but adequate packaging of the electronic gear for transportation to and from depot activities. This approach has proven more satisfactory from both a cost and capability point of view than the previous practice of building a throwaway package for each movement of equipment.

## CHAPTER IV

### ASSESSING SPARE PARTS REQUIREMENTS

Effective spares support for new weapon systems requires initial spares provisioning requirements to be computed accurately and consistently with other spares and logistic spares decisions. A significant amount of money is allocated to purchase initial spares and repair parts for new weapon systems. Often some of these spare parts are not needed during a system's life. Many errors have been made in the past when estimating initial spares. Money has been wasted because some of these spares have not been needed during the life of a weapon system.

Computing initial spares support requirements is a complex task. A number of factors such as failure rate, repair level (intermediate, depot, or nonrepair), pipeline times, procurement lead times, and flying hour program are needed. Using these estimated factors, initial spares support list (ISSL) levels to define individual base requirements are computed.

The utmost accuracy in estimating spares requirements and the most economical procurement methods possible must be used with planned expenditures because errors can be very costly. Better ways to develop better initial spares support lists must be found. Improvements are

possible. Where this is not possible, phased provisioning can be used as another method to preclude acquisition of no demand items. Other important factors which impact the ISSL procurement process include funding, computation methodology, maintenance factors, coordination problems and uncertainties regarding how new parts will operate.

Spares are identified, normally by the contractor after significant analyses which look at utilization rates, operating hours, failure rates, and mission consideration. There are several potential problems with developing ISSLs in this manner. First, contractors are normally strong in the engineering area and weak in the support area. They are usually competent to develop, test, and modify a system until it works properly without much care for ISSLs development. The problem is further exacerbated by failing to provide required deployment plans, planned utilization rates and maintenance concepts. Another problem involves rates and maintenance concepts. Another problem involves contractors' profit motives. A contractor developing an item expects to win the first, and perhaps subsequent production awards. Therefore, during the preparation for the first production contract, a company has the opportunity to clean its warehouse shelves by including every part which could conceivably be needed by the aircraft system over its life cycle. Contractors' recommendations must be carefully



weighed in order to procure only the essential parts. The ideal procedure to review the proposed ISSL is to compare it to actual consumption data derived from the development program to that time.

Assuming that at least enough spares are available may involve buying somewhat more than enough as a matter of policy. This may be considered a form of insurance to protect against loss of operational capability -- a form of insurance obtainable in no other way. Permitting an expensive fleet of aircraft to be less than fully effective for lack of spare parts can hardly be justified. "It follows that logistics planners may err on 'the high side' in estimating material required to support the weapon system, that some degree of long supply or excess material will occur, and that within prudent limits these costs may be deemed necessary in the interest of maintaining required operational capability." (13:8)

#### Provisioning Factors

"The principal objective of provisioning is to assure the timely availability of minimum initial stocks of support items at using organizations and at maintenance and supply activities to sustain the programmed operation of end items until normal replenishment can be effected, and to provide this support at the least initial investment

cost."(14:2) DOD instruction 3232.4 defines provisioning of end items as: "The process of determining the range and quantity of items (i.e., spares and repair parts, special tools, test equipment, and support equipment) required to support and maintain an end item of material for an initial period of service."(15:1-2)

The accuracy of provisioning requirements is dependent on the accuracy of factors used in provisioning computations. Estimated factors are used to compute initial provisioning requirements. Three provisioning pipeline factors used in computations are depot repair cycle time, base repair cycle time, and base order and shipping time. Repair cycle and order and shipping pipeline times are tailored to individual items using experience gained on similar items. Maintenance concept and base location can have a significant impact on pipeline times and a corresponding impact on requirements computation.(16:9)

#### Initial Spares Support List

Initial spares support lists (ISSLs) are developed to provide a range of spare parts support for activation of new weapon systems. ISSL levels are established to provide spares and repair parts for maintenance support of new weapon systems for an initial period of time. ISSLs are intended to provide a quantity of spares for an initial two-year period

to fill spare parts pipelines for aircraft or other end items. The two-year period allows actual usage to establish demand based support levels at the specific bases. The quantity of spares needed to support the base repair and order and shipping time pipelines is primarily affected by the length of the pipelines, item forecast failure rates, and the projected base flying hour program.

#### ISSL Pipeline

An ISSL requirement is composed of three pipeline segments which include (1) the order and shipping time from depot or contractor to base, (2) the base repair cycle time, and (3) the combination of depot or contractor and base repair times which consider the percentage of failed items that can be repaired at base level as well as those items not reparable at this station which must be sent to the depot for repair.

The base order and shipping time quantity is the quantity of spares required to support the period of time between a base initiating a request for a serviceable item and receiving the item. The base repair cycle is the quantity of spares required to support the period of time it takes for base maintenance personnel to repair an unserviceable item and making it available for reissue.(16:14)

#### Item Forecast Failure Rates

Forecast failure rates directly affect ISSLs requirements. Failure rates for new aircraft spares often improve during the first few years of operation because of product improvement, modifications and improved maintenance capability. As the failure rates for an item improves, fewer spares are required to support a given flying hour program. The point in time selected to obtain a flying hour program, when new aircraft are being activated at a base, has a direct effect on the ISSL requirements. Specifically, aircraft and the associated flying hour program continue to increase until all authorized aircraft are received.

#### ISSL Computational Methodology

The methodology used to compute ISSL levels during initial provisioning is discussed in AFLCR 57-27. The ISSL requirements should include the following factors: order and shipping time, base maintenance concept changes, forecast failure rates improvements and stable flying hour program for activating bases.

The complexity of the new system will normally determine whether manual or computer aided calculations will be employed. Also taken into consideration will be the number of maintenance and supply actions per level of maintenance. If the great majority of failures will be

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corrected in the field (organizational or intermediate level) and very few items will be returned to the depot for overhaul, computer aided calculations may be used to develop the base-level ISSL while the depot-level ISSL may be manually calculated. Inputs to ISSLs; i.e., accurate failure rates, repair rates, resupply times, commonality with other systems, sharing between similarly equipped units, repair times, number of systems and planned utilization rates, must be considered in order to arrive at an ISSL.(17:12) Once an ISSL has been developed, the task now changes to that of procuring the spares in the most efficient and cost effective manner possible. Spares acquisition integrated with production (SAIP) is one technique for acquiring spares for a new system. The philosophy is to obtain the spare parts at the least cost by ordering these parts with items produced for use on the primary system.(18:1)

Another technique for procuring spares is phased provisioning. Phased provisioning is applied to selected items; i.e., high value or complex parts of a system, because early in the production phase basing plans, maintenance programs, and operational concepts may not be fully developed. Phased provisioning also offers a hedge against having unneeded spares inventory when funding cutbacks or development problems cause production on-line delays.(19:5) Phased provisioning for initial support of weapon systems

should be strongly considered when operational test data cannot be used.

From an operational point of view, the contractor needs to know the number of aircraft to be supported, the expected number of flying hours, and the basing choices. On the maintenance side, the contractor will need to know the planned level of repair, time to repair and pipeline time. (17:21)

#### Spares Repair

The United States Air Force logistic system places emphasis and importance on repair versus replenishment because of the obvious economic tradeoffs involved. According to AFLC spares recoverable computation system, repair is seven times cheaper than new procurement. (20:2) There is not enough money available to fund other important procurement and operation programs and at the same time buy more than the minimum quantity of weapon system spares. The correct calculation of the minimum spares requirement (repairs and procurement) for a given weapon system is important to logistic managers.

How and where the maintenance and modification services are performed depends upon the interrelationships of many factors beside fund availability. These other factors include facilities, production equipment, skilled manpower,

and urgency of need. Some work is performed by contractors because of organic resource constraints (skills, equipment, facilities, technical data, etc.). The goal of initial provisioning of spares for a new aircraft system is to provide an acceptable level of readiness at least cost. Air Force Logistic Command Regulation (AFLCR) 57-27 provides policy and procedures for determining initial requirements for Air Force expense, investment, and equipment items. The policy prescribed in DODI 4140.42 relating to initial spares/repair part requirements, is implemented by AFLCR 57-27. "The earliest computation of spares requirements for the F-16 aircraft was based on AFLCR 57-27 which provides for the use of models as well as its set of computational rules." (21:3-2)

#### War Readiness Spare Kit (WRSK)

The WRSK is "a kit consisting of selected spares and repair parts needed to sustain operations (without resupply) at a base, deployed or dispersed location for the first month of conventional activity in USAF War Plans." (22:4) "The number one objective of the WRSK is to enable the tactical fighter squadron to operate independently under various situations and at diverse locations for the first thirty days of conventional war." (23:16) Air Force Manual 67-1 establishes eleven criteria that establish the selection



parameters of the spares and repair parts that are to be placed in a WRSK. Guidelines established by Air Force Manual 67-1 to initiate a WRSK listing are:

1. The item and quantities selected will be the minimum that is necessary to support the required mission as reflected in the war plans.
2. Failure rates or maintenance data gathered through the AFM 66-1 reporting system will be considered in determining the range and quantities of the items required.
3. Normally the usage data related to the peacetime flying hour program when appropriately adjusted to the wartime flying hours and sorties missions will provide demand rates necessary to compute the WRM requirements for the activities.

In order to properly evaluate these criteria it is necessary to consider the environment and methods of operation of the WRSK when deployed with a squadron. When a squadron deploys, it may go to one of four categories of bases. These categories are:

Forward operating base (FOB): An air base on which facilities for flying operations exist. Austere billeting, messing and operational support facilities may or may not be available. No personnel support is provided.

Limited operating base (LOB): An austere manned, active air base that has no permanently assigned operational tactical forces but is capable, with personnel augmentation, of receiving deployed forces.

Dispersed operating base (DOB): An active USAF air base that does not have permanently assigned tactical forces, but is capable of receiving deployed forces.

Main operating base (MOB): A major active USAF air base that has deployed theater or rotational tactical forces (or other major active flying training or flying support mission) in peacetime and can support these and other forces in sustained wartime apparatus. (24:1-1)

Other factors which must be considered before items are selected for the WRSK are the logistic management while deployed, maintenance concept, and resupply support.

The support base to which the squadron is deployed is responsible to provide all follow-on support required by the deployed squadron. The maintenance concept while deployed is important because a major source of supply is repair. Each tactical squadron, when deployed, performs organizational maintenance on assigned aircraft. The deployed unit operates on remove and replace concept. "The theater commander is responsible to provide field level maintenance (less "hot reaction" jet engine base maintenance) from his resources and augmented by specialists who deployed with the unit."(24:4-4) While deployed, resupply comes from two sources: repair in the field (field maintenance) or from resupply channels.

## CHAPTER V

### OPERATING AND SUPPORT COST

Life cycle cost must be considered when acquiring a new aircraft. The concept of a system's LCC can be summarized as:

The total cost to the government for a system over its full life. It includes the cost of development, procurement, operation, support, and disposal.(25:1)

Life cycle cost is divided into four major cost categories of research and development, production, operations and support, and disposal.

#### Research and Development

Research and development costs include the costs for feasibility studies; simulation or modeling; engineering design, development, fabrication, assembly, and test of prototype hardware; initial system evaluation; associated documentation; and test of software.

#### Production Costs

Production costs are those costs associated with producing the aircraft, initial support equipment, training, technical and management data, initial spares and repair parts, plus many other items required to introduce a new system to the field.

#### Operating and Support Cost

It is the cost of personnel, material, and

facilities of both a direct and indirect nature required to operate, maintain, and support the hardware and software of the system.

#### Disposal Cost

Disposal is the cost associated with disposing of a system at the end of its useful life, minus any salvage value. This value is very small in comparison to other categories or the aircraft will be placed in storage at the end of their useful life.

The importance of operating and support cost comes from the recognition that over 60 percent of a major system's total cost is derived from operating and supporting that system over its life cycle. The remaining 40 percent of this total cost is attributed to research, development, and acquisition of the system.(26:2)

#### Estimation Techniques

Current DOD cost models use two basic methods: one employing a cost estimating relationship and the other using various engineered cost estimating criteria. Models using the cost estimating relationship method are called parametric models since they rely on statistically derived parameters such as dimensions, performance and production cost in their estimating equations. Models using engineered cost estimating methods are referred to as accounting models and

are made up of a set of equations that consider many elements of a system's hardware, procedures and functions. The equations are designed to describe mathematically the way various elements interact when the system is operated and supported. Estimations are expected to change over time as more knowledge is gained about the system and how it will be operated and maintained once delivered to the user.(27:3-1)

When properly accomplished, the engineering model will yield the most accurate results. However, a large amount of data and a large number of analytical manhours are often required. With this method, the manhours required to perform each task, the material, and the energy consumed are determined.

#### AFR 173-13 CORE Model

AFR 173-13 Air Force Cost and Planning Factors Regulation includes a mathematical model based on OSD, CAIG (Office of the Secretary of Defense, Cost Analysis Improvement Group) cost structure. The recommended cost structure of this guide is shown in table 1.(27:4-2) The cost structure includes both direct manpower and material resources consumed by the aircraft system as well as many categories of indirect resources such as base support, personnel acquisition and training, and various depot

activities. This model is the Cost Oriented Resource Estimating model, known as the "CORE Model." (28:1)

AFR 173-13 provides a summary information on existing weapon systems. A summary of the percent contribution of each cost element to the total annual squadron O&S costs for various aircraft is shown in table 2. The most important elements are unit mission personnel, aviation fuel, depot maintenance and replenishment spares.

#### Unit Mission Personnel

Unit mission personnel cost is the cost for the pay and allowances of those persons directly assigned in support of the unit's mission. It is divided into the following elements:

1. Aircrew
2. Maintenance (organizational, intermediate, ordnance)
3. Other unit personnel (unit's staff, security, remaining unit personnel)

The aircrew element is the number of crews required to operate the aircraft in the unit. The maintenance personnel constitute the largest number of people in all aircraft squadrons. They are tasked with inspecting, servicing, and repairing of the aircraft, ordnance, support equipment, and unit level training devices. Maintenance manhours per flying hour (MMH/FH) of a system is a technical measure of its reliability and maintainability. It is the

number of maintenance manhours at base level spent servicing, inspecting, and repairing the aircraft and its components, both on and off the aircraft, for every hour the aircraft is flown. If the MMH/FH, the annual flying hours, and the number of manhours a person is expected to work each year is known, then the number of people needed can be calculated.

$$\text{Maintenance Personnel} = \frac{(\text{MMH/FH}) (\text{PAA}) (\text{FH/PAA-Yr})}{\text{AMPH} (12 \text{ months/Yr}) (\text{EFF})}$$

PAA - Primary Authorized Aircraft per Squadron

AMPH - Available Manhours per month per person  
during peacetime = 145 Hrs

EFF - Manpower efficiency factor

The lower portion of the equation calculates the number of productive manhours available per person per year. A 60% efficiency factor is used to account for the cyclic nature of the workload which does not allow people to be effectively employed 100% of the time.

The cost for other unit personnel is the sum of its three elements: unit staff, security, and remaining unit personnel. Unit staff element accounts for the administrative staff of the unit. These are the individuals who perform the functions of command, flying supervision, operation control, planning, scheduling, flight safety, and unit administration. Security personnel is the element directly responsible for maintaining the security of the weapon system.

### Fuel Consumption

Fuel is referred to as "POL" which means petroleum, oil, and lubricants. The fuel elements for most CORE type models provide the annual cost of squadron fuel using the following equation.

$$POL = (CPG) (GPFH) (PAA) (FH)$$

where: POL - Annual Squadron Fuel Cost  
CPG - Cost of Fuel per Gallon  
GPFH - Average Gallons of Fuel Burned  
per Flying Hour  
PAA - Authorized aircraft

### Depot Maintenance

The depot maintenance addresses those depot level activities that are necessary to inspect, modify, and repair the total aircraft and its components. It includes any system maintenance that is not performed at the base level. It includes: airframe rework, engine rework, component repair, support equipment, software, and modification labor. The equation used in CORE models to calculate total annual depot maintenance results is:

$$DLM = DM/FH (PAA) (FH/PAA) + (DM/PAA) (PAA)$$

where: DLM - Annual Squadron Depot Level  
Maintenance Cost  
DM/FH - Depot Maintenance Cost Per  
Flying Hour  
DM/PAA - Annual Depot Maintenance Per  
PAA Factor



### Replenishment Spares

This category accounts for the recurring cost of procuring spare parts and components. It is normally estimated as the average cost per flying hour. Annual squadron replenishment spares are calculated in CORE models with a relationship as:

$$RS = (RSPFH) (PAA) (FH)$$

RS - Annual Squadron Replenishment Spares Cost  
RSPFH- Average Replenishment Spares Cost Per  
Flying Hour  
PAA - Primary Authorized Aircraft Per Squadron  
FH - Flying Hours Per PAA Per Year

The items in this category are only those that are normally repaired and returned to supply stocks after they fail. They are called reparable items. They are also commonly called recoverable items. Initial spares are those reparable items procured to achieve a required stock level for a defined set of conditions. They are also called pipeline spares.

Replenishment spares are those reparable items procured to maintain a required stock level as items are lost to the supply system due to condemnation. These are also called condemnation spares. Condemnation spares are used for estimating annual squadron O&S costs. The sum of the pipeline spares and the total condemnation spares over the O&S period constitute the total life cycle spares for the system.

The analyst must determine all of the reparable items on the aircraft. This includes both line replaceable units (LRUs) and shop replaceable units (SRUs) within the LRUs. For each of these reparable items the unit cost, the quantity on the aircraft, the mean time between removals (MTBR), and the condemnation rate are estimated. The MTBR is the average number of hours between item removal from the next higher hardware level. The condemnation rate is the fraction of decimal percent of removed items that are condemned usually. Items are condemned when the cost of repair exceeds 65% of the cost of a new item.

$$RSPFH = \sum_{i=1}^n \frac{(COND) (UC_i) (QPA)}{MTBR}$$

where: RSPFH - Replenishment Spares Cost Per Flying Hour  
i - Individual Item Identification  
n - Total Number of Different Items  
MTBR - Mean Time Between Removals in Flying Hours  
COND - Fraction of Removal Condemned  
UC - Unit Cost  
QPA - Quantity Per Aircraft

OPERATING AND SUPPORT COSTS

UNIT MISSION PERSONNEL

Aircrew  
Military  
Maintenance  
Military  
Civilian  
Other Unit Personnel  
Military  
Civilian

UNIT LEVEL CONSUMPTION

Petroleum, Oil, & Lubricants  
Maintenance Material  
Training Ordnance

DEPOT LEVEL MAINTENANCE

Airframe Rework  
Engine Rework  
Component Repair  
Support Equipment Rework  
Software  
Modification Labor  
Other Depot Maintenance  
Contracted Unit Level Support

SUSTAINING INVESTMENT

Replenishment Spares  
Replacement Support Equipment  
Modification Kits  
Other Recurring Investments

INSTALLATION SUPPORT PERSONNEL

Base Operating Support  
Military  
Civilian  
Real Property Maintenance  
Military  
Civilian  
Medical  
Military  
Civilian

INDIRECT PERSONNEL SUPPORT

Misc Operations and Maintenance  
Medical O&M Non-Pay  
Permanent Change of Station  
Temporary Additional Duty Pay

DEPOT NON-MAINTENANCE

General Depot Support  
Second Destination Transportation

PERSONNEL ACQUISITION AND TRAINING

Acquisition  
Individual Training

Table 1 - OSD(CAIG) Aircraft O&S Cost Structure

	<u>B-52G</u>	<u>KC-135</u>	<u>C-5A</u>	<u>F-15</u>
UNIT MISSION PERSONNEL				
Aircrew	4.82	6.51	5.39	2.26
Maintenance	10.35	10.91	17.09	18.72
Other	7.40	3.64	0.91	2.82
UNIT LEVEL CONSUMPTION				
Aviation Fuel	41.43	45.84	30.09	22.06
Maint Material	3.44	2.51	4.03	3.85
Training Ordnance	1.39	-	-	0.38
DEPOT MAINTENANCE	12.81	11.40	19.13	12.54
SUSTAINING INVESTMENTS				
Replenishment Spares	3.83	3.14	6.66	16.58
Support Equipment	0.53	0.77	0.39	4.28
Modification Kits	2.78	3.11	4.11	4.34
INSTALLATION SPT PERS				
Base Op Support	2.90	2.78	3.76	3.67
Real Prop Maint	0.36	0.29	0.47	0.16
Medical	0.30	0.30	0.45	0.30
INDIRECT PER SUPPORT				
Misc O&M	1.67	1.59	1.88	1.98
Medical Support	0.68	0.66	0.69	0.82
PCS Moves	0.87	0.82	0.78	0.92
PERS ACQ AND TRAINING				
Acquisition	1.59	1.45	1.14	1.28
Individual Training				
Pilot	1.42	3.03	1.66	1.81
Navigator	0.48	0.40	0.39	-
Other	0.95	0.85	0.88	1.23
	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

Table 2 - Percent Distribution of O&S Cost Elements.

## CHAPTER VI

### CONCLUSION

Operational readiness of aircraft is directly dependent upon logistic support. No matter how impressive the performance of the weapon system, if it is not effectively supported, it may not be ready when needed. Because current aircraft rely heavily on logistic support to perform their mission, logistic support planning should be considered in the early stages of procurement.

The aircraft to be procured must have a high system mean time between failure, and high reliability of individual components. Reliability and ease of maintenance must be in the design of the aircraft. Reliability and maintainability are key factors that influence system effectiveness, logistic support requirements and life cycle cost.

Quantities of individual parts that will be used in the future need to be estimated as precisely as possible to avoid buying too many or too few. Readiness could be adversely affected by not having the needed parts. The cost of spares is a major cost of the logistic support for an aircraft; therefore, proper estimation can result in significant savings.

Recently, operating and support costs have grown so rapidly they now dominate as the major element in a weapon

system's total life cycle cost. Generally, when acquiring new aircraft, attention is focused on the cost of buying the system, while life cycle cost, or the cost of buying and maintaining a weapon system over its expected life is given less attention. Life cycle costs should be considered in the early stages of planning because they affect future logistic support.

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